

# **Long-Term Ground-Water Hydrograph Analysis for the Palouse Basin Aquifer**

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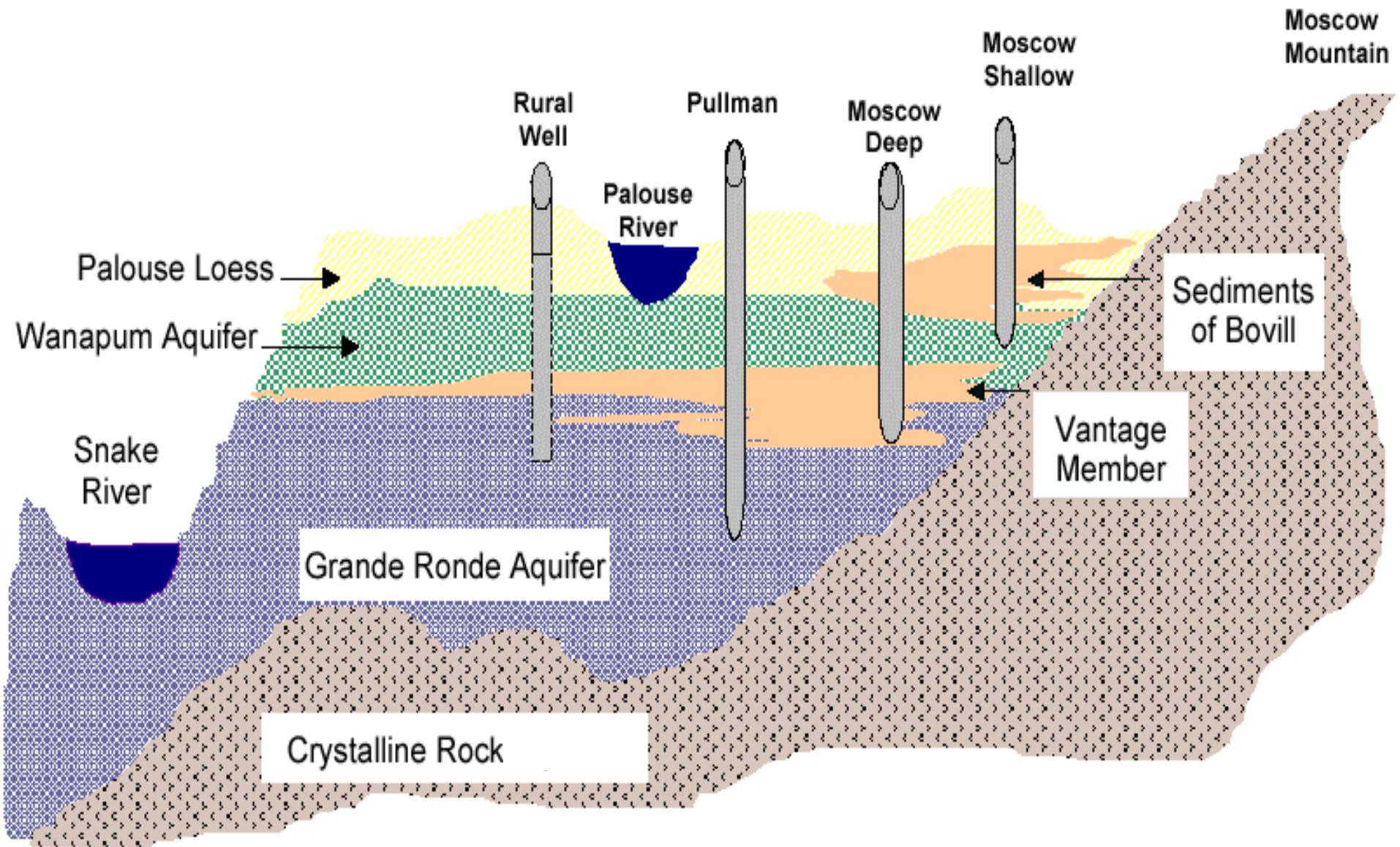
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# Outline

- Introduction
- Palouse Basin Aquifer (PBA) history
- Objectives
- Long-term hydrograph analysis
- Preliminary findings
- Current and future efforts
- Summary

# Introduction

- PBA is divided into four zones:
  - Palouse loess
  - Basaltic Wanapum
  - Basaltic Grande Ronde
  - Crystalline basement



# Introduction (cont'd)

- Ground water is the sole water supply source for the Pullman-Moscow area
- Surface waters are limited but can become potential sources for recharge and discharge



# PBA History

- 1897

- Russell was the first researcher to publish a report on the basin's water problems

- 1960's

- Early studies predict water supply to last until 2000
- USCOE looks at importing water from Snake River, Clearwater and Palouse River

# PBA History (cont'd)

- 1980's

- USGS (*Barker, 1979*) developed the first 3-d computer model of the basin; setting Union Flat Creek as constant-head boundary
- Water levels continued to decline steadily
- WDOE and IDWR were concerned about ground-water mining

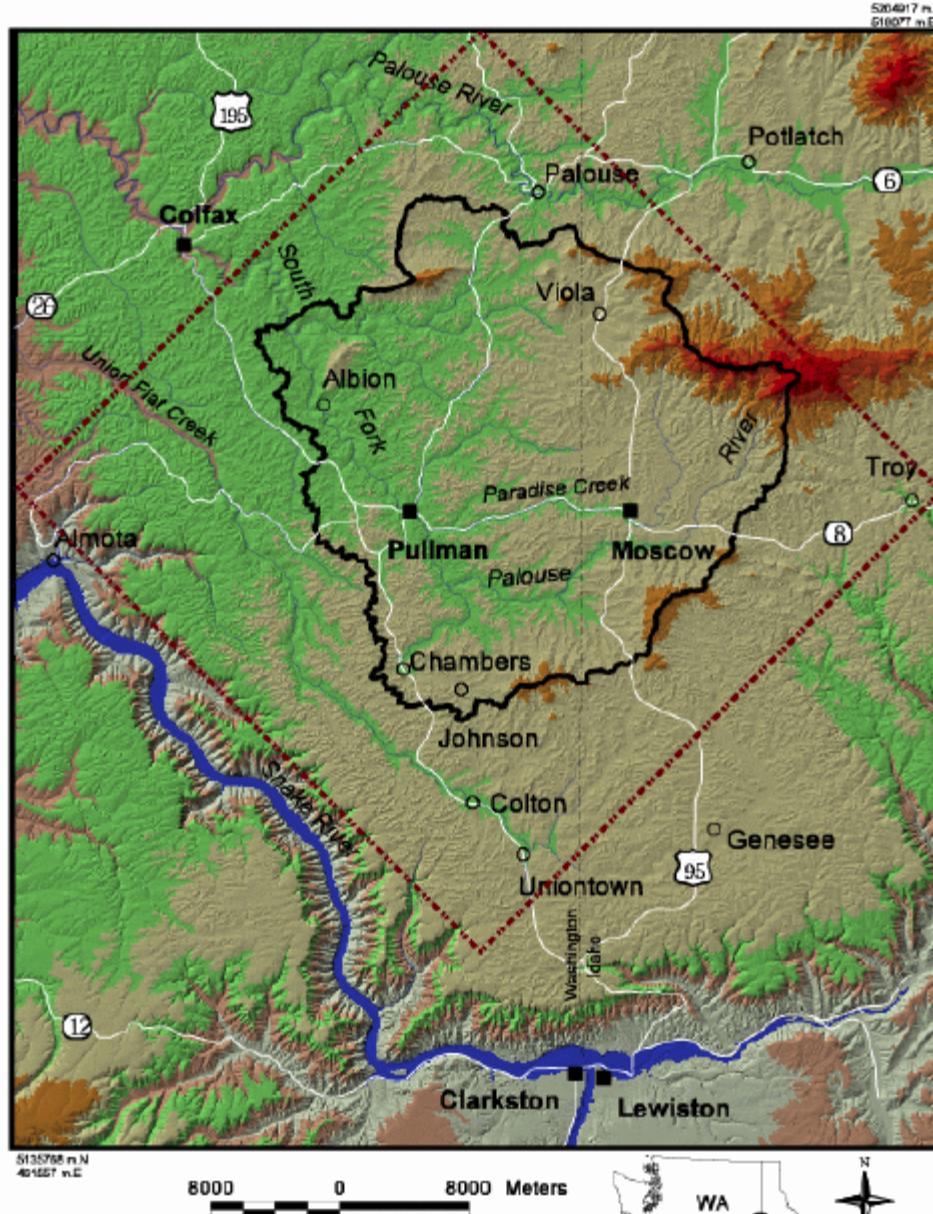
# PBA History (cont'd)

- 1990's

- USGS (*Lum et al.*, 1990) developed another 3-d model
- Simulated large springs along the Snake River
- Predicted that water level decline would stop if pumping rates were stabilized

- 2000's

- Water levels continue to decline— meaning recharge estimates by *Lum et al.* too high



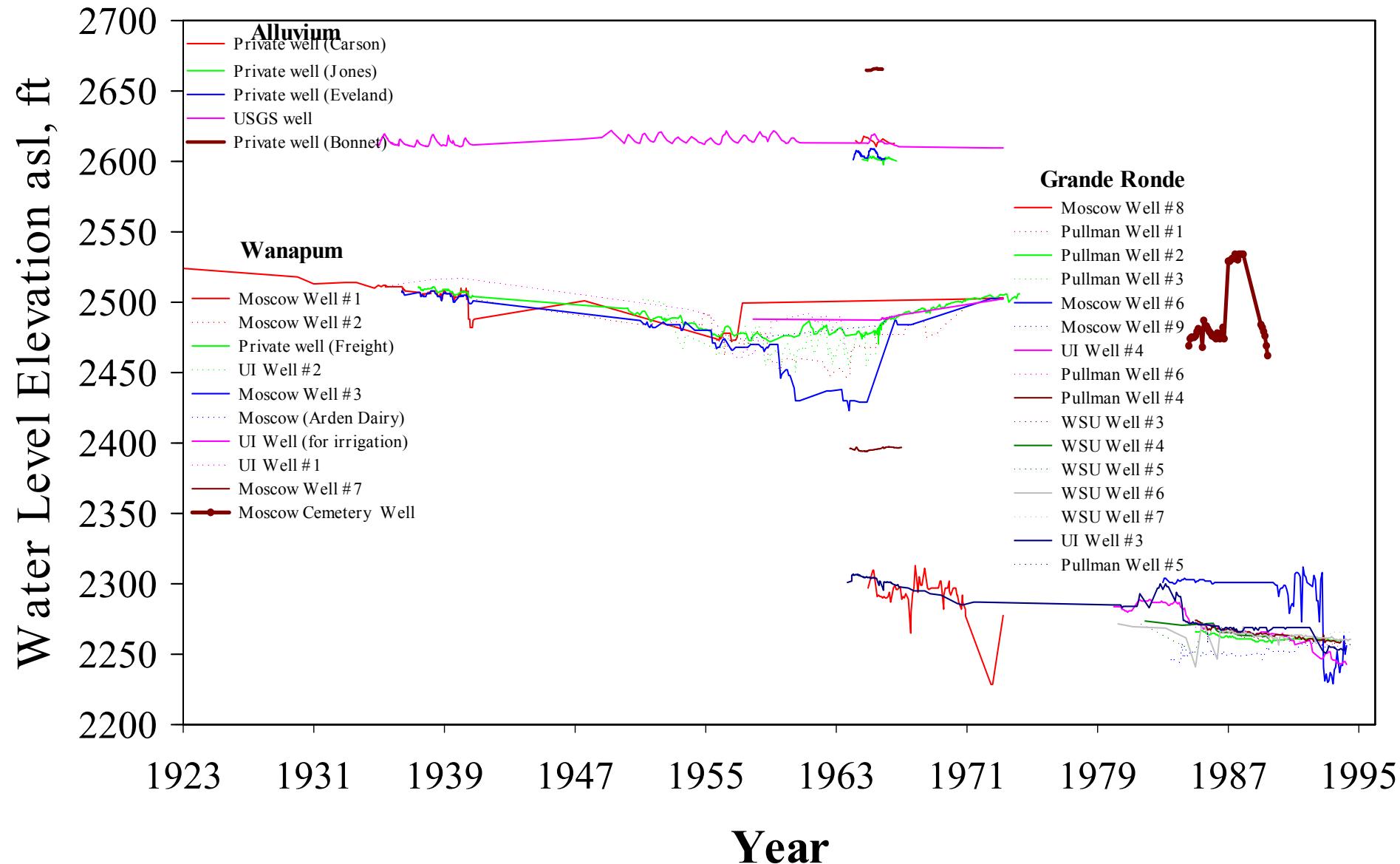
# Objectives

- To graph and visually inspect spatially distributed, long-term data of ground-water hydrograph, pumpage, and precipitation
- To obtain the interrelationships between these quantities based on statistical analysis
- To infer what are the major factors causing ground-water level decline at PBA

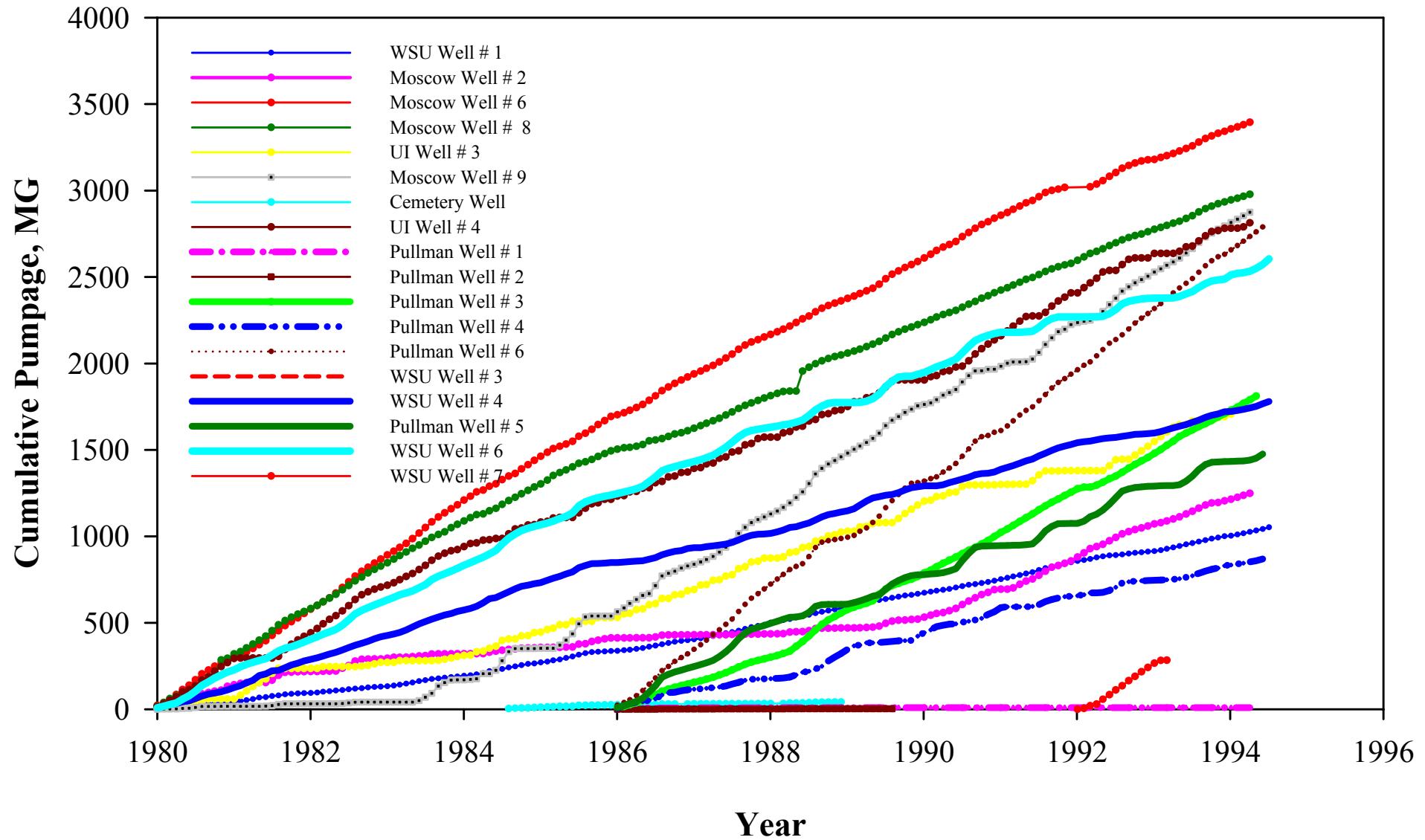
# Long-Term Hydrograph Analysis

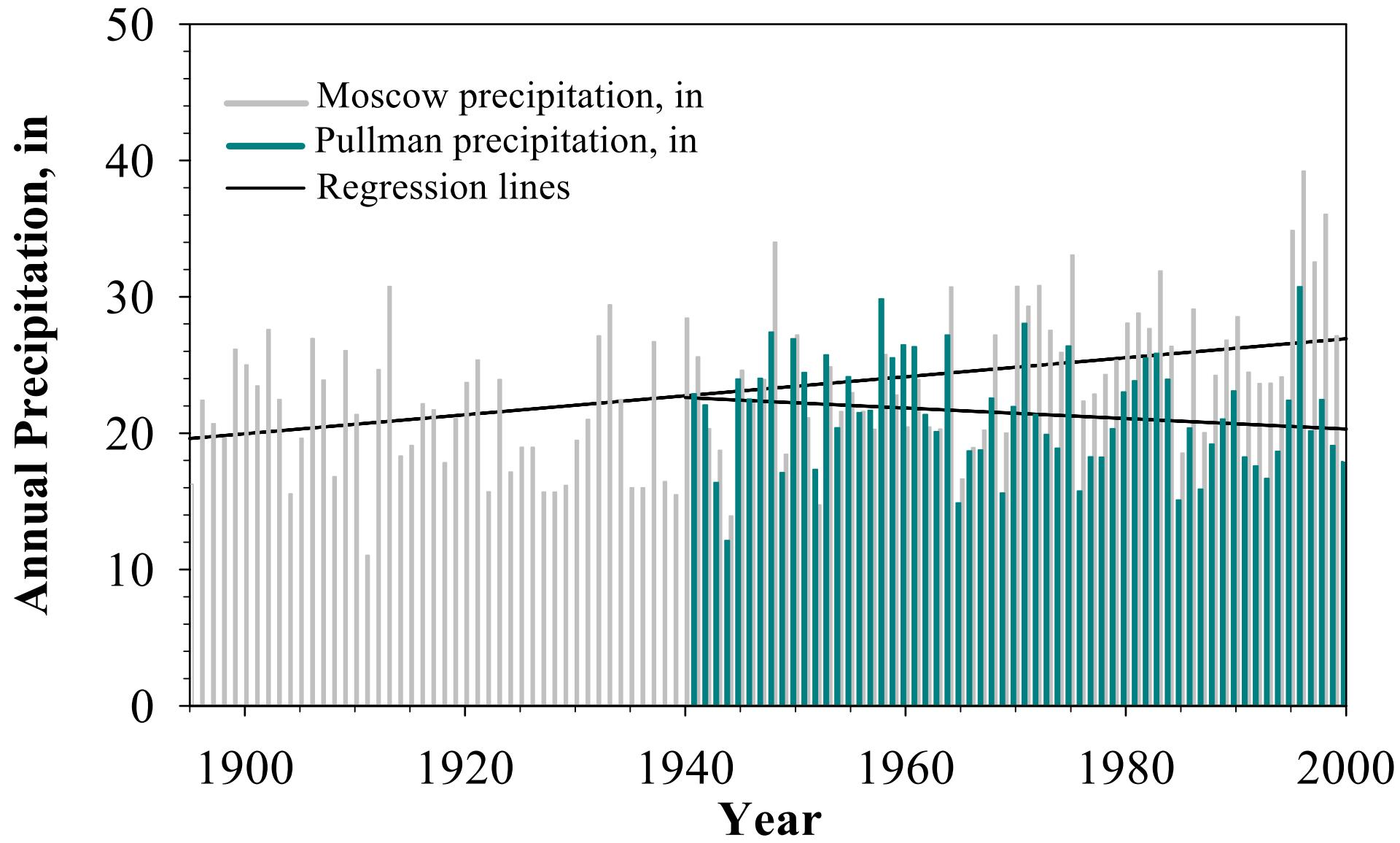
- Graphing all historical data on water level, pumpage, and precipitation
- Statistical analysis
  - Correlation between annual water level, pumpage, cumulative pumpage, precipitation, cumulative precipitation

# Composite Hydrograph for Palouse Basin Aquifer

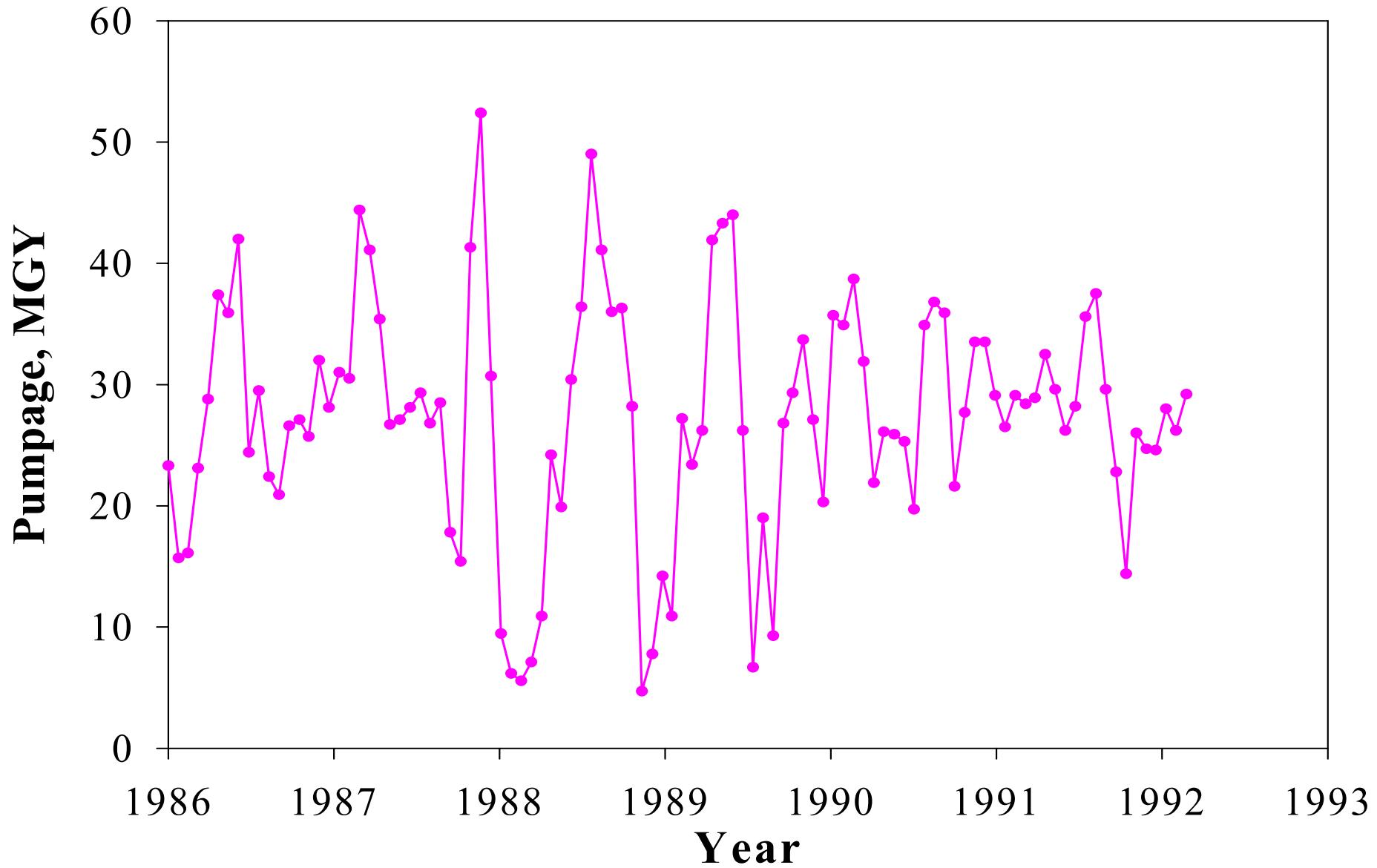


# Ground-Water Pumpage for Wells of the Palouse Basin Aquifer

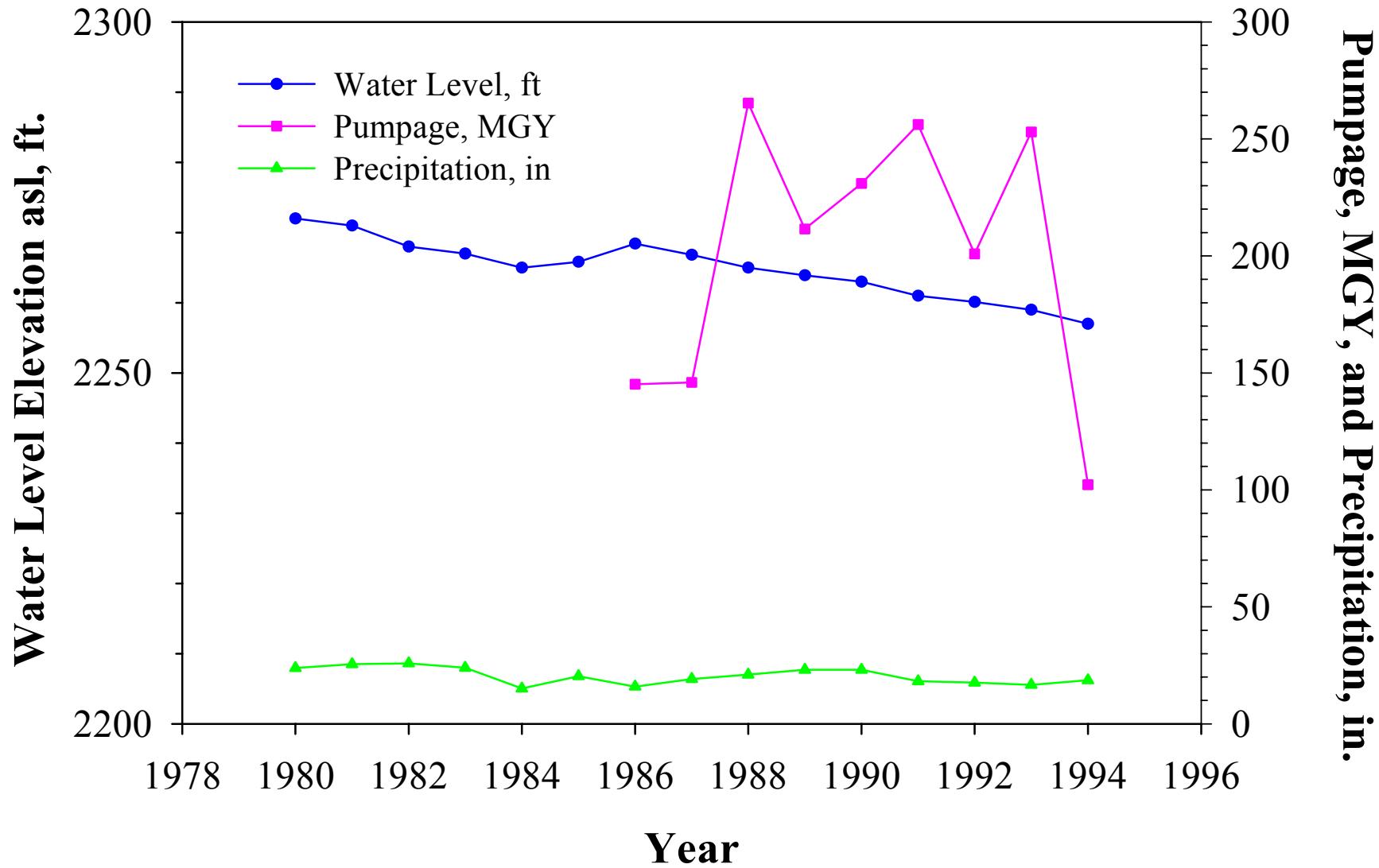




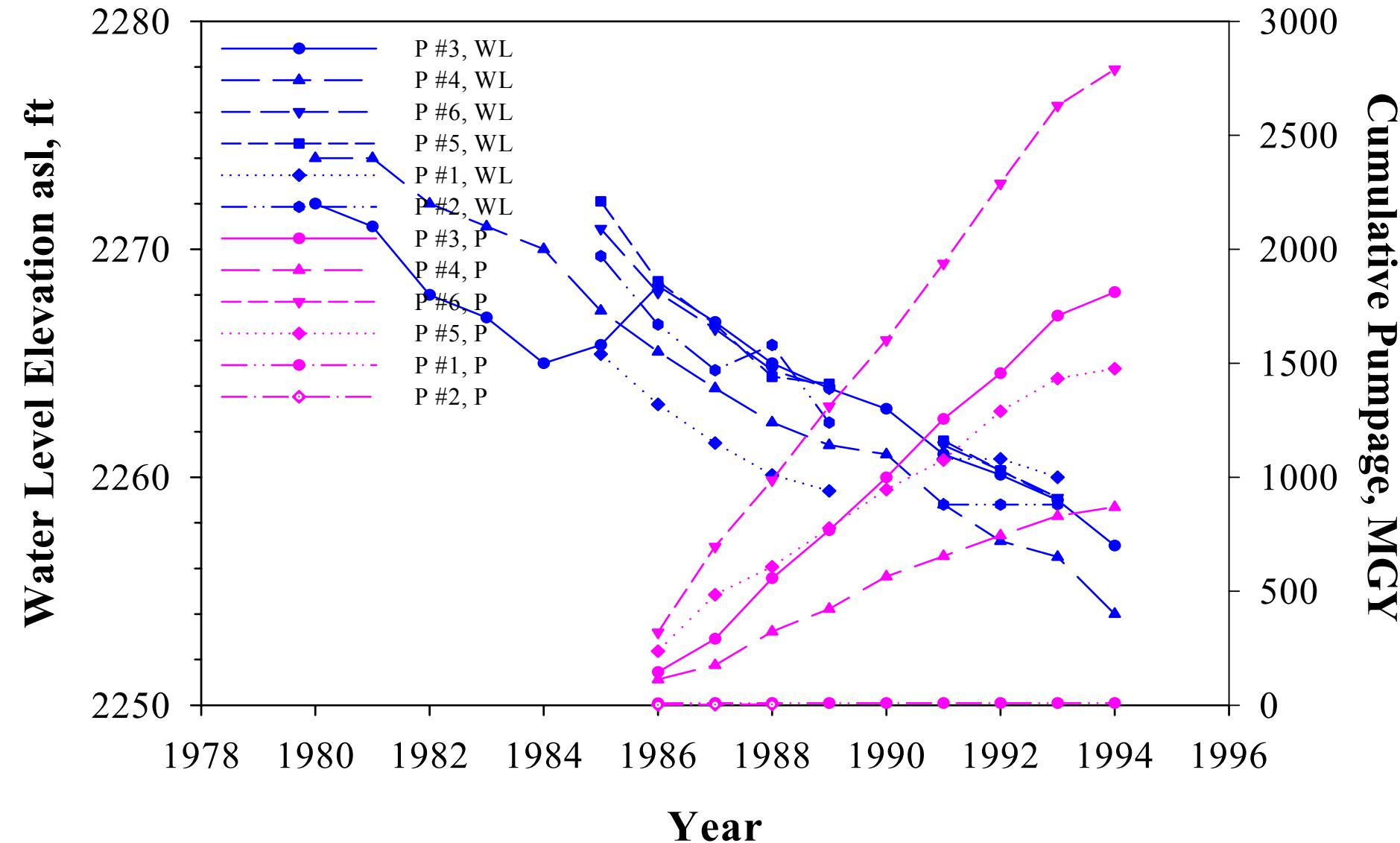
# Pumpage for City of Pullman Well # 6



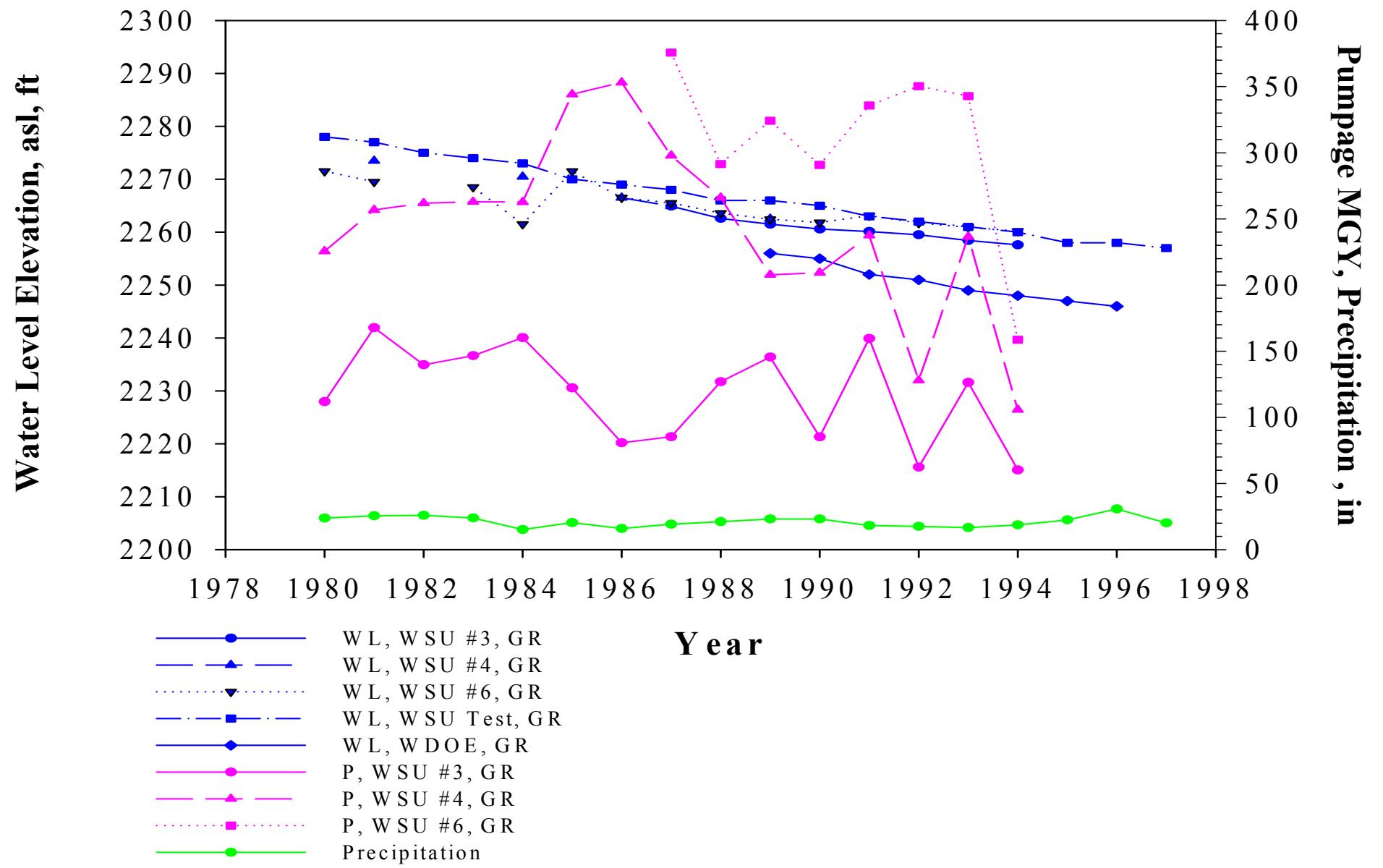
# Water Level, Pumpage and Precipitation for Pullman Well #3



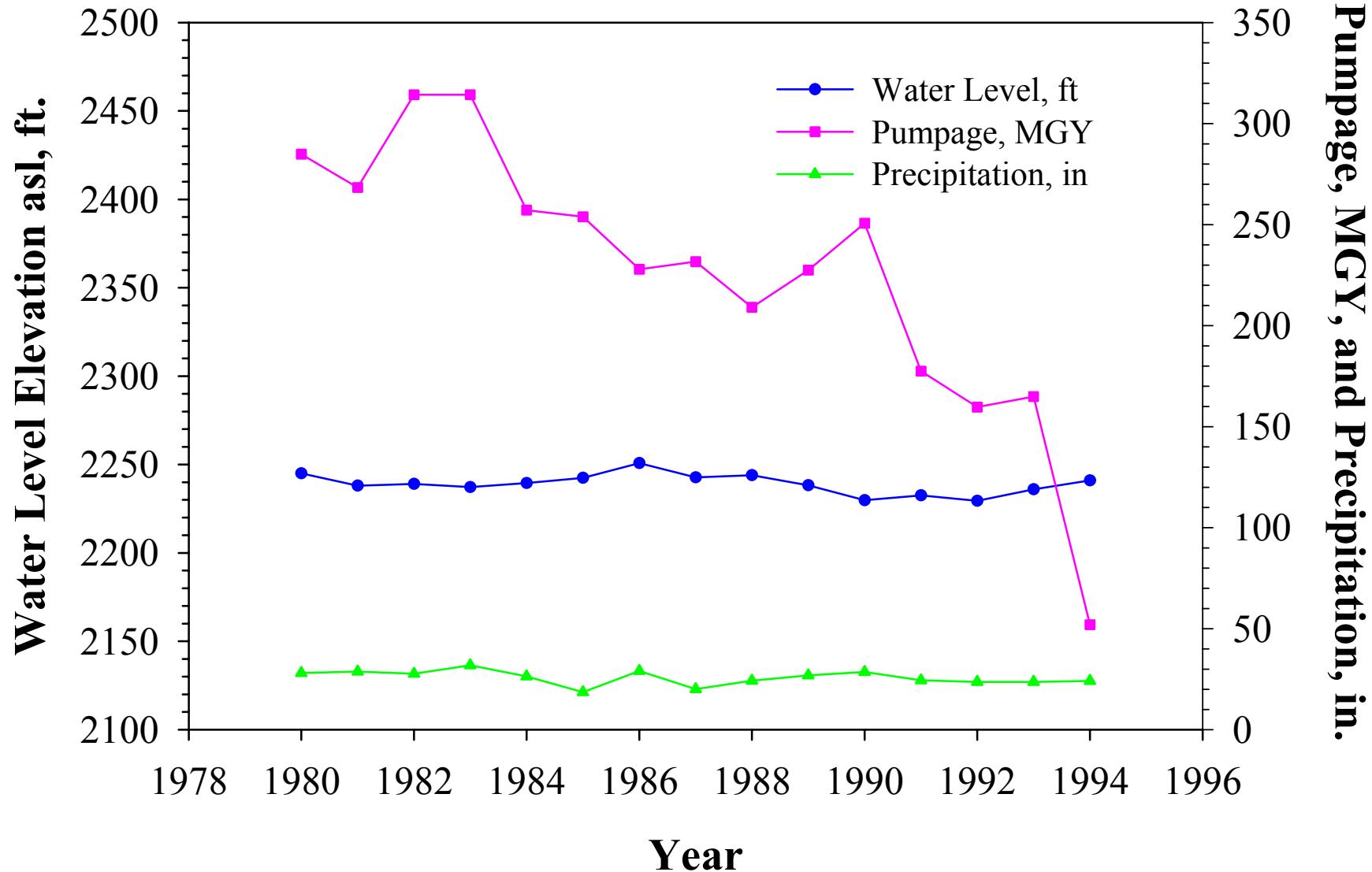
# Water Level and Cumulative Pumpage for Pullman Wells



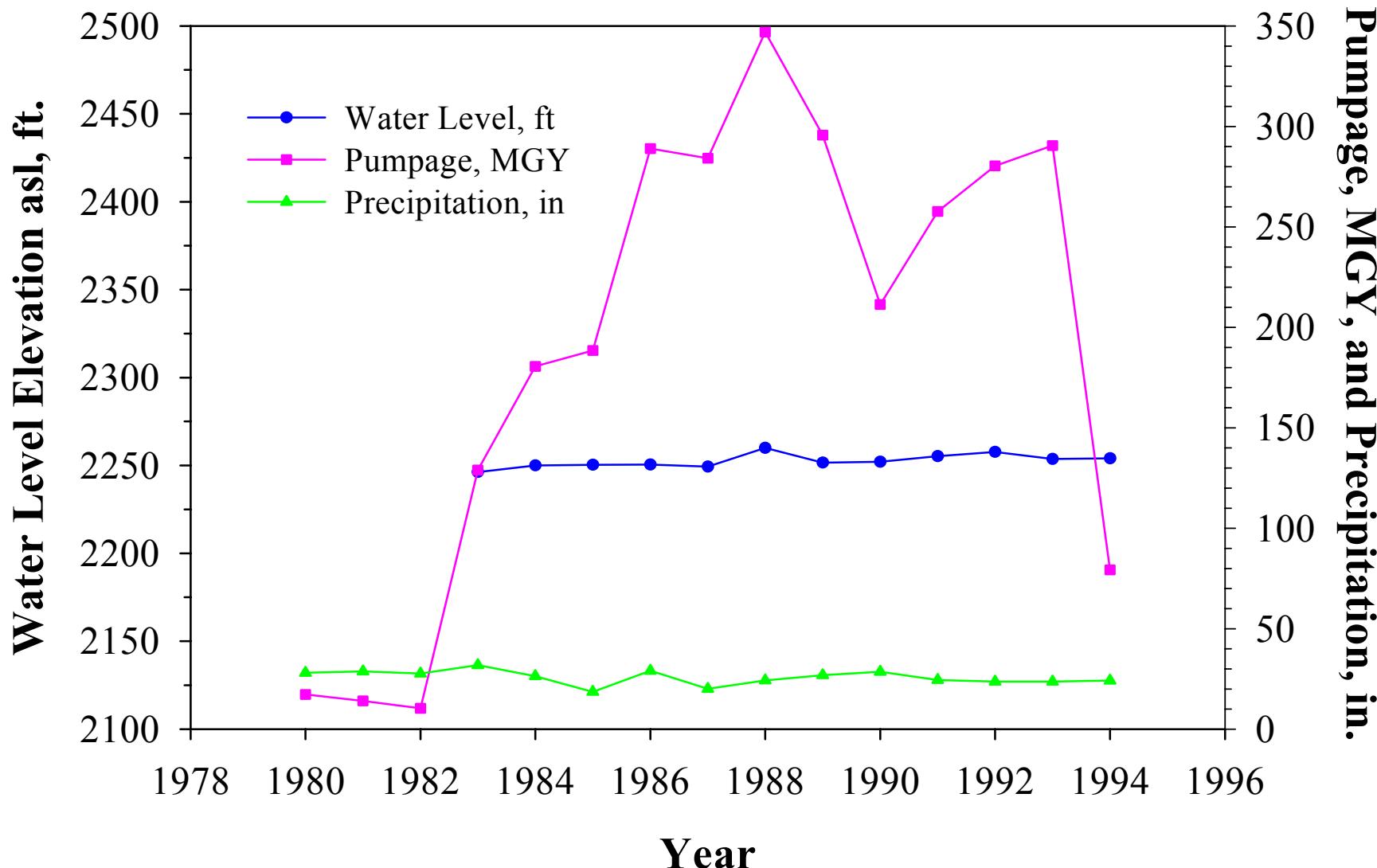
# Water Level, Precipitation and Pumpage for WSU Wells



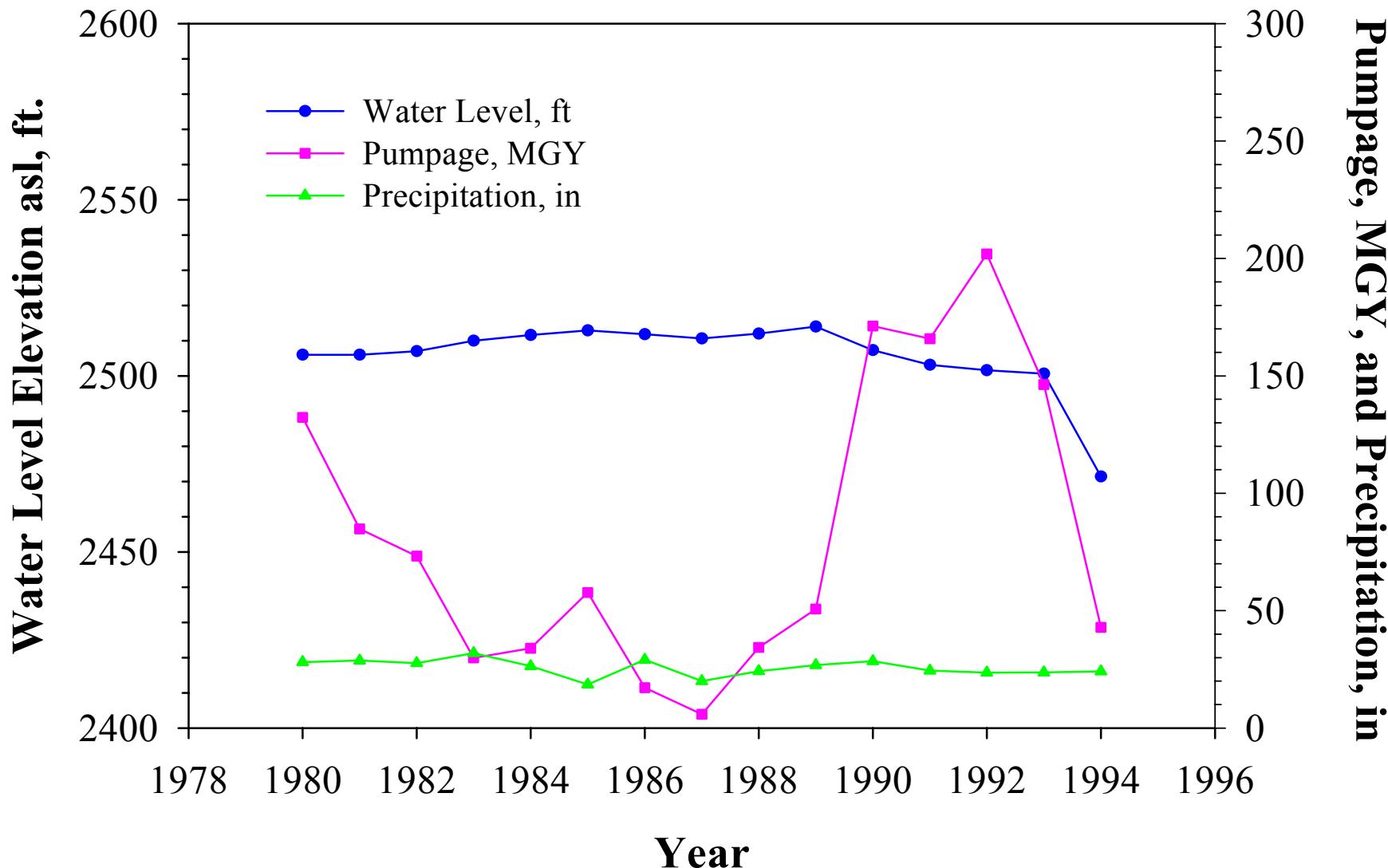
# Water Level, Pumpage and Precipitation for Moscow Well #6



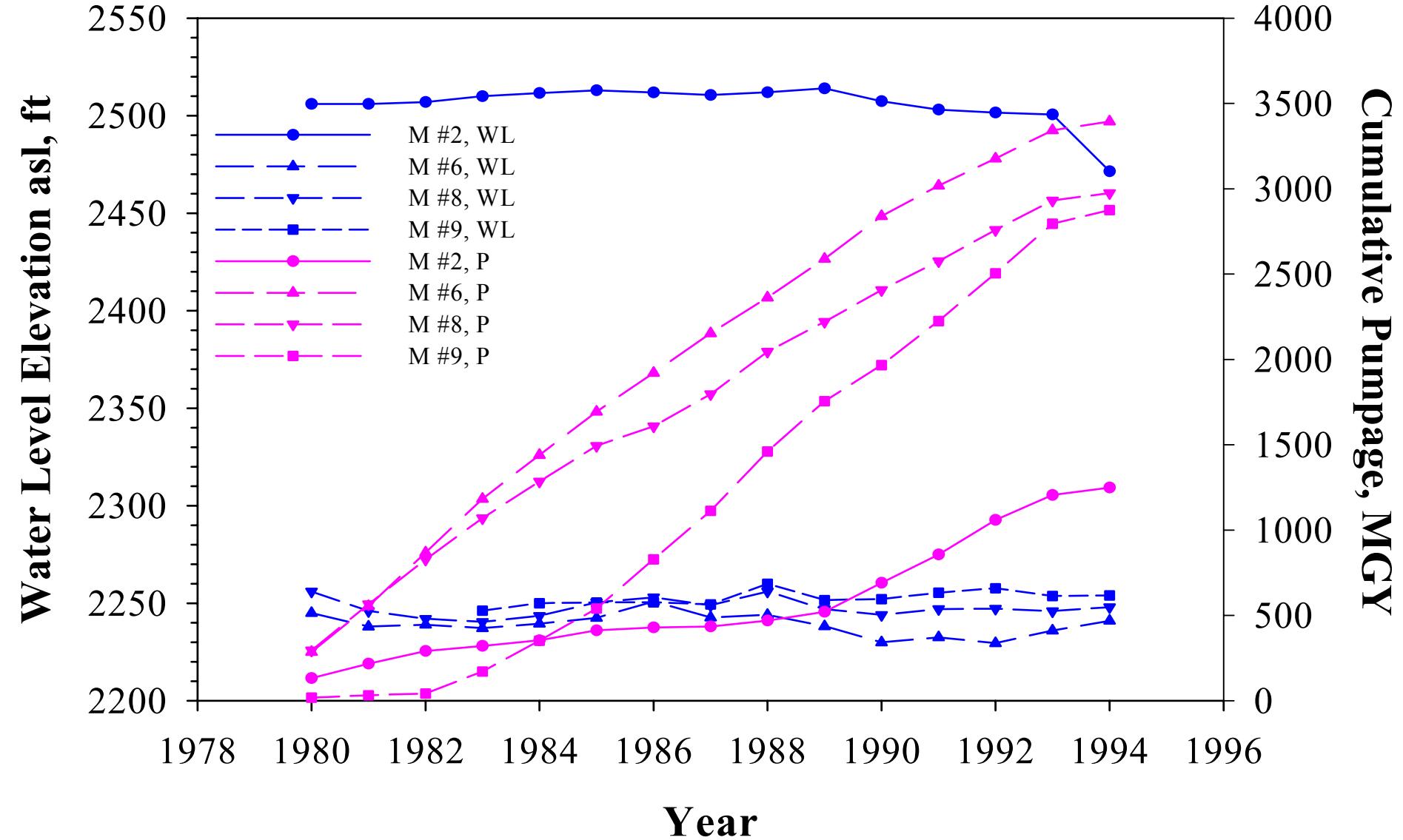
# Water Level, Pumpage and Precipitation for Moscow Well #9



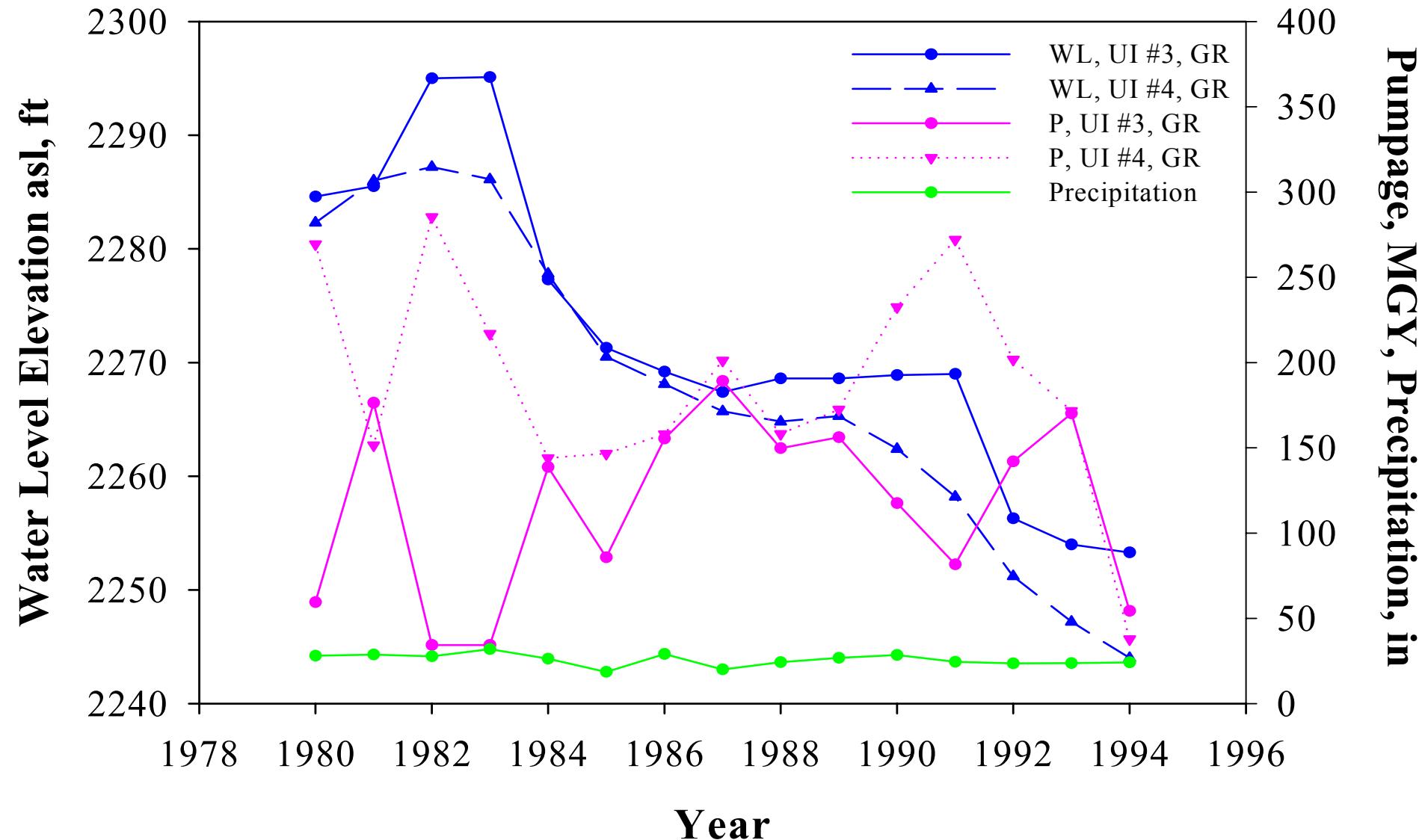
# Water Level, Pumpage and Precipitation for Moscow Well #2



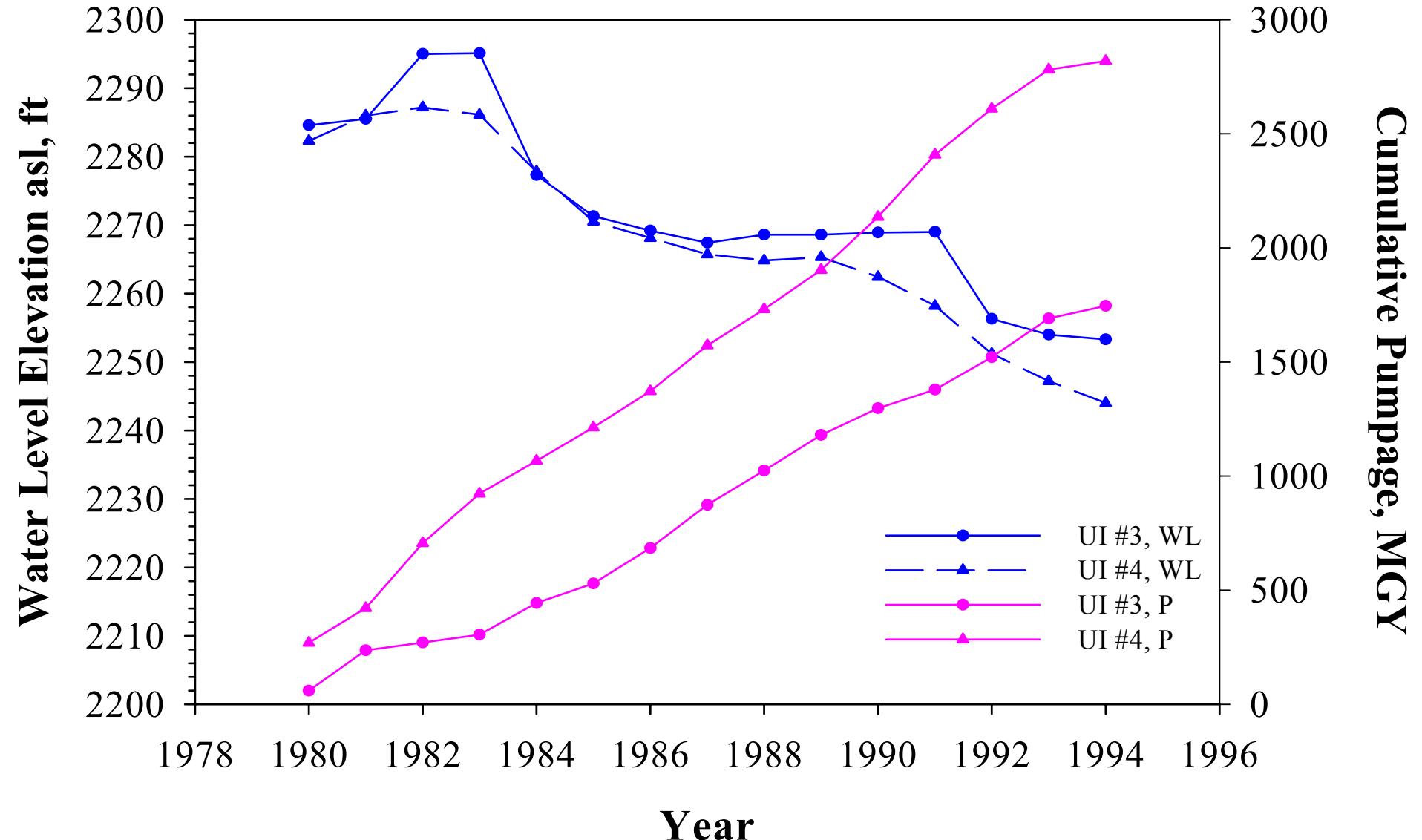
# Water Level and Cumulative Pumpage for Moscow Wells



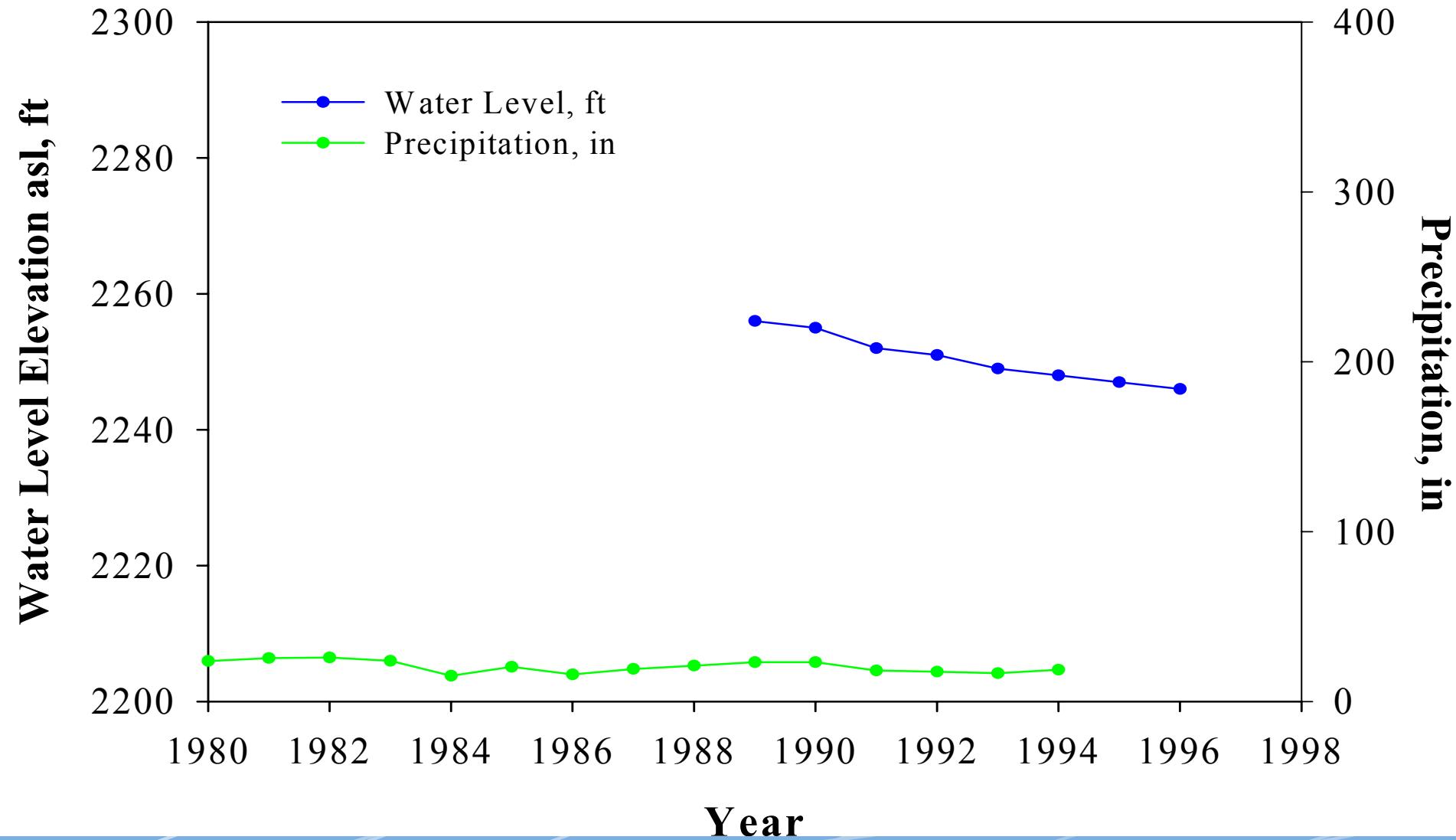
# Water Level, Pumpage and Precipitation for UI Wells



# Water Level and Cumulative Pumpage for UI Wells



# Water Level and Precipitation for WDOE Well



# Correlation Matrix, Moscow #9 (1983–1994)

|                            | <i>Water Level</i> | <i>Pumpage</i> | <i>Cumula.<br/>Pumpage</i> | <i>Precip.</i> | <i>Cumula.<br/>Precip.</i> |
|----------------------------|--------------------|----------------|----------------------------|----------------|----------------------------|
| <i>Water Level</i>         | 1.00               |                |                            |                |                            |
| <i>Pumpage</i>             | <u>0.47</u>        | 1.00           |                            |                |                            |
| <i>Cumula.<br/>Pumpage</i> | <u>0.65</u>        | 0.14           | 1.00                       |                |                            |
| <i>Precip.</i>             | <u>-0.29</u>       | -0.19          | -0.20                      | 1.00           |                            |
| <i>Cumula.<br/>Precip.</i> | <u>0.64</u>        | 0.10           | 1.00                       | -0.22          | 1.00                       |

# Correlation Matrix, Moscow #2 (1980 –1994)

|                            | <i>Water Level</i>  | <i>Pumpage</i> | <i>Cumula.<br/>Pumpage</i> | <i>Precip.</i> | <i>Cumula.<br/>Precip.</i> |
|----------------------------|---------------------|----------------|----------------------------|----------------|----------------------------|
| <i>Water Level</i>         | 1.00                |                |                            |                |                            |
| <i>Pumpage</i>             | <b>-0.17</b>        | 1.00           |                            |                |                            |
| <i>Cumula.<br/>Pumpage</i> | <b>-0.69</b>        | 0.44           | 1.00                       |                |                            |
| <i>Precip.</i>             | <b>0.11</b>         | 0.00           | -0.35                      | 1.00           |                            |
| <i>Cumula.<br/>Precip.</i> | <b><u>-0.51</u></b> | 0.33           | 0.94                       | -0.40          | 1.00                       |

# Correlation Matrix, Pullman #3 (1986 – 1994)

|                            | <i>Water Level</i> | <i>Pumpage</i> | <i>Cumula.<br/>Pumpage</i> | <i>Precip.</i> | <i>Cumula.<br/>Precip.</i> |
|----------------------------|--------------------|----------------|----------------------------|----------------|----------------------------|
| <i>Water Level</i>         | 1.00               |                |                            |                |                            |
| <i>Pumpage</i>             | <b>-0.06</b>       | 1.00           |                            |                |                            |
| <i>Cumula.<br/>Pumpage</i> | <b>-1.00</b>       | 0.10           | 1.00                       |                |                            |
| <i>Precip.</i>             | <b>0.12</b>        | 0.27           | -0.17                      | 1.00           |                            |
| <i>Cumula.<br/>Precip.</i> | <b><u>0.00</u></b> | 0.00           | 0.00                       | 0.00           | 1.00                       |

# Correlation Matrix, Pullman #4 (1986 – 1994)

|                            | <i>Water Level</i> | <i>Pumpage</i> | <i>Cumula.<br/>Pumpage</i> | <i>Precip.</i> | <i>Cumula.<br/>Precip.</i> |
|----------------------------|--------------------|----------------|----------------------------|----------------|----------------------------|
| <i>Water Level</i>         | 1.00               |                |                            |                |                            |
| <i>Pumpage</i>             | <u>0.52</u>        | 1.00           |                            |                |                            |
| <i>Cumula.<br/>Pumpage</i> | <b>-1.00</b>       | -0.38          | 1.00                       |                |                            |
| <i>Precip.</i>             | <b>0.17</b>        | 0.42           | -0.12                      | 1.00           |                            |
| <i>Cumula.<br/>Precip.</i> | <b>-1.00</b>       | -0.434         | 1.00                       | -0.114         | 1.00                       |

# Correlation Matrix, UI #3 (1980 – 1994)

|                            | <i>Water Level</i>  | <i>Pumpage</i> | <i>Cumula.<br/>Pumpage</i> | <i>Precip.</i> | <i>Cumula.<br/>Precip.</i> |
|----------------------------|---------------------|----------------|----------------------------|----------------|----------------------------|
| <i>Water Level</i>         | 1.00                |                |                            |                |                            |
| <i>Pumpage</i>             | <b>-0.44</b>        | 1.00           |                            |                |                            |
| <i>Cumula.<br/>Pumpage</i> | <b>-0.89</b>        | 0.25           | 1.00                       |                |                            |
| <i>Precip.</i>             | <b>0.58</b>         | -0.26          | -0.38                      | 1.00           |                            |
| <i>Cumula.<br/>Precip.</i> | <b><u>-0.89</u></b> | 0.22           | 1.00                       | -0.40          | 1.00                       |

# Correlation Matrix, UI #4 (1980 – 1994)

|                            | <i>Water Level</i> | <i>Pumpage</i> | <i>Cumula.<br/>Pumpage</i> | <i>Precip.</i> | <i>Cumula.<br/>Precip.</i> |
|----------------------------|--------------------|----------------|----------------------------|----------------|----------------------------|
| <i>Water Level</i>         | 1.00               |                |                            |                |                            |
| <i>Pumpage</i>             | <u>0.41</u>        | 1.00           |                            |                |                            |
| <i>Cumula.<br/>Pumpage</i> | <b>-1.00</b>       | -0.31          | 1.00                       |                |                            |
| <i>Precip.</i>             | <b>0.51</b>        | 0.26           | -0.4                       | 1.00           |                            |
| <i>Cumula.<br/>Precip.</i> | <b>-1.00</b>       | -0.35          | 1.00                       | -0.40          | 1.00                       |

# Correlation Matrix, WDOE (1989 – 1996)

|                            | <i>Water<br/>Level</i> | <i>Precip.</i> | <i>Cumula.<br/>Precip.</i> |
|----------------------------|------------------------|----------------|----------------------------|
| <i>Water<br/>Level</i>     | 1.00                   |                |                            |
| <i>Precip.</i>             | <b>0.44</b>            | 1.00           |                            |
| <i>Cumula.<br/>Precip.</i> | <b><u>-1.00</u></b>    | -0.35          | 1.00                       |

# Preliminary Findings

- Patterns of temporal water level fluctuations in each aquifer do not significantly correspond to precipitation.
- Water levels in Wanapum have been recovering.
- Water levels in Grande Ronde continue to decline at 1–2 ft per year.
- Pumping appears to have been exceeding recharge.
- Water level decline in Grande Ronde is steady despite less pumping in 1990's.

# Current and future effort

- Continue historical data analysis including time-series analysis
- Develop a comprehensive GIS database pertaining to PBA hydrogeology
- Perform ground-water flow modeling
  - 2-*d* cross-sections (e.g. Moscow #9–DOE – Pullman #3)
  - to estimate local hydraulic parameters and characterize flow conditions
  - To explore possibilities of constructing large-scale, 3-*d* models based on smaller-scale, 2-*d* models

# Summary

- Consistent increase in pumpage in the last century has almost certainly contributed to declining water levels
- Two modeling studies led to different and inadequate predictions
- For optimal groundwater management, further studies to better understand and characterize the PBA system is needed
- Current effort is focused on additional historical data analysis and GIS database development

# Thanks!